CLAIMS

1. Corrected parameter control method for a two-shaft gas turbine, characterized in that protection of the said turbine is provided by a first control loop which controls the opening of the fuel valves to keep the temperature Tfire of the gas at the inlet of the first wheel of the said turbine and the fuel-air ration F/A within specified limits; the said control is provided in such a way that the set-point exhaust temperature TX is calculated as the sum of a reference temperature TXbase to which are added corrections relating to a single environmental or operating parameter which differs from the reference parameter.

2. Control method according to Claim 1, characterized in that the said corrections are calculated by computer simulations of the said gas turbine, the said simulations being conducted by specifying the attainment of a maximum of the said temperature Tfire or a maximum of the said fuel-air ratio F/A, for each condition differing from the reference condition.

3. Control method according to Claim 1, characterized in that there are four of the said corrections, the said exhaust temperature TX being expressed by the following formula:

TX = TXbase + DeltaTX_DPin + DeltaTX_DPout + DeltaTX_Hum + DeltaTX_PCNLP

where

DeltaTX_Dpin is the correction of the temperature TX due to the variation of the pressure drops in intake pipes with respect to a nominal value of 0 mmH2O,

DeltaTX_Dpout is the correction of the temperature TX due to the variation of the pressure drops in exhaust pipes with respect to a nominal value of 0 mmH2O,

DeltaTX_Hum is the correction of the temperature TX due to the variation of the relative humidity of the air with respect to a nominal value of 60%,

DeltaTX_PCNLP is the correction of the temperature TX due to the variation of the speed of the low pressure shaft with respect to a nominal value of 100%.

4. Control method according to Claim 2, characterized in that the said exhaust temperature TX found by the said simulations is compared with the said reference temperature TXbase, in order to evaluate the said correction terms appropriately, as differences.

5. Control method according to Claim 3, characterized in that a maximum exhaust temperature curve is generated for each considered speed of the said low

pressure turbine.

6. Control method according to Claim 5, characterized in that an equation for evaluating the said current exhaust temperature TX is:

TX = TXbase(PCNLP) + DeltaTX_DPin + DeltaTX_DPout + DeltaTX_Hum

where TXbase(PCNLP) is the reference temperature found for the said specific speed of the said low pressure turbine.

7. Control method according to Claim 6, characterized in that there are two values of TXbase(PCNLP), one related to a curve (21) of maximum temperature Tfire and one related to a curve (23) of maximum increase of temperature Trise of the gas in the combustion chamber.

8. Control method according to Claim 7, characterized in that the said two maximum values are, respectively,

TX_maxTfire = TXbase_maxTfire(PCNLP,PR) + DeltaTX_DPin + DeltaTX_Dpout + DeltaTX_Hum

TX_maxTrise = TXbase_maxTrise(PCNLP,PR) + DeltaTX_DPin + DeltaTX_Dpout + DeltaTX_Hum,

where a dependence on the compression ratio PR is also expressed.

9. Control method according to Claim 8, characterized in that the said temperature curves TXbase_maxTfire and TXbase_maxTrise are provided in the form of two-dimensional tables, with the compression ratio PR and the low pressure turbine speed PCNLP as independent variables.

10. Control method according to Claim 8, characterized in that a diagram of the said maximum temperature TX, shown as a function of the compression ratio PR which enables the maximum Tfire to be attained, shows a set of curves (27), each for a specific value of speed PCNLP, the said curve (27) generally having an increasingly negative slope as this speed increases, and being always of the type decreasing with a rise in the compression ratio PR.

11. Control method according to Claim 8, characterized in that a diagram of the maximum temperature TX, shown as a function of the compression ratio PR, which enables the maximum Trise to be attained, shows a set of curves (29), each for a specific value of speed PCNLP, the said curve (29) generally having an increasingly negative slope as this speed increases, and being always of the type decreasing with a rise in the compression ratio PR.

12. Control method according to Claim 3, characterized in that the said correction DeltaTX_Hum depends on the specific humidity SH and is expressed as a function of a difference DeltaSH, defined as the difference between the actual specific humidity and the specific humidity SH_60%RH at a relative humidity RH of 60% (in the same conditions of temperature and atmospheric pressure), according to the formula:

DeltaSH = SH_current - SH_60%RH.

13. Control method according to Claim 12, characterized in that there is a linear correlation (31) between the said DeltaTX_Hum and the said DeltaSH.

14. Control method according to Claim 13, characterized in that the said humidity SH_60%RH as a function of atmospheric temperature can be found by interpolating the following values, where the temperature is expressed in degrees Rankine:

SH_60%RH (T=419.67) = 0.000070;

SH_60%RH (T=428.67) = 0.000116;

SH_60%RH (T=437.67) = 0.000188;

SH_60%RH (T=446.67) = 0.000299;

SH_60%RH (T=455.67) = 0.000464;

SH_60%RH (T=464.67) = 0.000707;

SH_60%RH (T=473.67) = 0.001059;

SH_60%RH (T=482.67) = 0.001560;

SH_60%RH (T=491.67) = 0.002263;

SH_60%RH (T=500.67) = 0.003324;

SH_60%RH (T=509.67) = 0.004657;

SH_60%RH (T=518.67) = 0.006367;

SH_60%RH (T=527.67) = 0.008670;

SH_60%RH (T=536.67) = 0.011790;

SH_60%RH (T=545.67) = 0.015966;

SH_60%RH (T=554.67) = 0.021456;

SH_60%RH (T=563.67) = 0.028552;

SH_60%RH (T=572.67) = 0.037585;

SH_60%RH (T=581.67) = 0.048949.

15. Control method according to Claim 3, characterized in that the said correction DeltaTX_Dpin is expressed directly as a function of a measured pressure drop DPin.

16. Control method according to Claim 15, characterized in that there is a linear correlation (33) between DeltaTX_Dpin and the said Dpin.

17. Control method according to Claim 3, characterized in that the said correction DeltaTX_Dpout is expressed directly as a function of a measured pressure drop DPout.

18. Control method according to Claim 17, characterized in that there is a linear correlation (35) between the said DeltaTX_Dpout and the said Dpout.

19. Corrected parameter control method for a two-shaft gas turbine, characterized in that the control of the said turbine at partial loads is provided by a second control loop which controls the opening of a vent valve to keep the temperature rise Trise of the gas in the combustion chamber (and consequently the fuel-air ratio F/A) within specified limits; the said control is provided by means of sets of maps of the exhaust temperature TX as a function of the compression ratio PR, obtained for each operating condition of the said gas turbine.

20. Control method according to Claim 19, characterized in that a control curve is defined for each value of atmospheric temperature.

21. Control method according to Claim 20, characterized in that there are diagrams showing the

relation between the said temperature TX, for partial loads at a given speed of the low pressure shaft, and the compression ratio PR, each relation curve (37) being associated with a specified value of atmospheric temperature, the said curve (37) generally having higher values as this temperature rises, and being of the type which decreases as the compression ratio PR decreases.

22. Control method according to Claim 21, characterized in that the said curves (37) are reduced to a single curve (39), thus eliminating the dependence on the atmospheric temperature.

23. Control method according to Claim 22, characterized in that the said curve (39) is obtained by the following mathematical transformation:

$$TTX = TX \cdot (518.67/TCD)^{x}$$

where

- TX is the actual exhaust temperature;
- 518.67 is a reference temperature;
- TCD is the exhaust temperature of the compressor, expressed in a unit of measurement compatible with that of the constant;
- X is a nondimensional exponent calculated in

such a way as to minimize the mean quadratic deviation between the values of TTX calculated in this way and the interpolation curve (39);

- TTX is the transformed exhaust temperature, in other words the reduced temperature.

24. Control method according to Claim 23, characterized in that the said curve (39), when the actual value of PR is known and after the application of the inverse of the said transformation, yields the reference temperature TXbase, from which the set point is calculated for the controller of the said second F/A control loop.

25. Control method according to Claim 24, characterized in that the said exhaust temperature TX is calculated by a linear approximation as the sum of the reference temperature TXbase to which are added corrections relating to a single environmental or operating parameter which differs from the reference parameter.

26. Control method according to Claim 25, characterized in that there are four of the said corrections, the said exhaust temperature TX being expressed by the following formula

TX = TXbase + DeltaTX_DPin + DeltaTX__Dpout + DeltaTX_Hum + DeltaTX_PCNLP

where

TXbase is found by inverting the said transformation, thus: TXbase = TTX/ ((518.67/TCD)^{x});

DeltaTX_Dpin is a correction of the temperature TX due to the variation of pressure drops in intake pipes with respect to a nominal value of 0 mmH2O;

DeltaTX_Dpout is a correction of the temperature TX due to the variation of pressure drops in exhaust pipes with respect to a nominal value of 0 mmH2O;

DeltaTX_Hum is a correction of the temperature TX due to the variation of relative humidity of the air with respect to a nominal value of 60%;

DeltaTX_PCNLP is a correction of the temperature TX due to the variation of the low pressure shaft speed with respect to a nominal value of 100%.

27. Control method according to Claim 26, characterized in that each correction term is calculated by computer simulations of the gas turbine, the desired F/A ratio being specified, for each condition differing from the reference condition and at different partial loads, the said exhaust temperature

TX found by the said simulations being compared with the reference temperature TXbase, in order to evaluate the correction terms in the appropriate way as differences.

28. Control method according to Claim 27, characterized in that a set of curves (41), one for each given value of speed PCNLP, is shown in a diagram of the said maximum temperature TX as a function of the compression ratio PR.

29. Control method according to Claim 28, characterized in that an equation for evaluating the current exhaust temperature TX is:

TX = TXbase(PCNLP) + DeltaTX_DPin + DeltaTX_Dpout + DeltaTX_RH

where TXbase(PCNLP) is the reference temperature found for the specific speed of the low pressure turbine.

30. Control method according to Claims 23 and 29, characterized in that the said exponent X is a function of the speed of the low pressure wheel.

31. Control method according to Claim 30, characterized in that the exponent X, for intermediate speeds PCNLP, can be calculated by interpolation of the values of X calculated at the speeds PCNLP considered:

if PCNLP = 105%, X = 0.323

if PCNLP = 100%, X = 0.33225

if PCNLP = 90%, X = 0.34

if PCNLP = 80%, X = 0.34425

if PCNLP = 70%, X = 0.351

if PCNLP = 60%, X = 0.348

if PCNLP = 50%, X = 0.3505.

32. Control method according to Claim 26, characterized in that the said correction DeltaTX_RH is calculated by considering:

- three ambient temperatures (very cold day, ISO standard conditions, very hot day);
- three levels of relative humidity (0%, 60%, 100%);
- load characteristics according to a cubic law.

33. Control method according to Claim 32, characterized in that nine simulations are conducted, the desired value of F/A being specified, in order to achieve the reference level, the current values of TX then being plotted on a diagram as functions of PR, while a difference between the said diagram and the base curves yields the said DeltaTX_RH, as expressed in the formula:

DeltaTX_RH = TX - TXbase.

34. Control method according to Claim 33, characterized in that the said values of DeltaTX_RH are plotted on the diagram as a function of the difference DeltaSH between the current value of specific humidity SH_current and the specific humidity at RH = 60%, SH_60%RH, which is the reference value, and thus

DeltaSH = SH_current - SH_60%RH.

35. Control method according to Claim 34, characterized in that the said diagram shows two straight lines (43 and 45), rising with an increase in DeltaSH, in which a first straight line (43), valid where DeltaSH is less than 0, has a greater slope than the second straight line (45) which is valid where DeltaSH is greater than 0, the two straight lines (43 and 45) passing through a point near the origin of the axes.

36. Control method according to Claim 26, characterized in that the said correction DeltaTX_Dpin is expressed directly as a function of the measured pressure drop DPin.

37. Control method according to Claim 36, characterized in that the following are considered:

- three ambient temperatures (very cold day, ISO standard conditions, very hot day);
- three pressure drops in the intake (0, 100 and 200 mm of water);
- load characteristics according to a cubic law.

38. Control method according to Claim 37, characterized in that nine simulations are conducted, the attainment of the desired value of F/A being specified, in order to achieve the reference level, the current values of TX then being plotted on a diagram as functions of PR, the difference between the said diagram and the base curves yielding the said DeltaTX_Dpin, this being expressed in the formula

DeltaTX_Dpin = TX - TXbase.

39. Control method according to Claim 38, characterized in that the said values of DeltaTX_Dpin are linearly correlated (47) with the said Dpin, the said values increasing with a rise in Dpin.

40. Control method according to Claim 26, characterized in that the said correction DeltaTX_Dpout is expressed directly as a function of the measured pressure drop DPout.

41. Control method according to Claim 40,

characterized in that the following are considered:

- three ambient temperatures (very cold day, ISO standard conditions, very hot day);
- three pressure drops in the exhaust (0, 100 and 200 mm of water);
- load characteristics according to a cubic law.

42. Control method according to Claim 41, characterized in that nine simulations are conducted, the attainment of the desired value of F/A being specified, in order to achieve the reference level, the current values of TX then being plotted on a diagram as functions of PR, a difference between the said diagram and the base curves yielding the said DeltaTX_Dpout, as expressed in the formula:

DeltaTX_Dpout = TX - TXbase.

43. Control method according to Claim 42, characterized in that the said values of DeltaTX_Dpout are linearly correlated (47) with the said Dpout, the said values increasing with a rise in Dpout.

44. Control method according to Claims 35, 39 and 43, characterized in that a correlation for calculating the maximum exhaust temperature TX is:

$$TX = TTX(PCNLP, PR) / ((518.67/TCD)^{X(PCNLP)}) +$$

DeltaTX_RH (DeltaSH) +

DeltaTX_Dpin (Dpin) +

DeltaTX_Dpout (Dpout).

45. Control method according to Claim 1 or 19, characterized in that the said two-shaft gas turbine is provided with a dry nitrogen oxide (NOx) reduction system.